Monitoring Rangelands in New Mexico:
Range, Riparian, Erosion, Water Quality, and Wildlife

Report 53

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Introduction

There are countless techniques described in the scientific and professional literature for monitoring rangeland resources. However, the majority of these have never gained broad appeal or implementation simply because they are too technical or time consuming. Our objective in this document is to outline a stepwise approach, from simple to complex, for rangeland monitoring. We take a three-level approach that is designed to encourage ranchers to start monitoring *now*, beginning with the straightforward Level One procedure. As ranchers become more comfortable with monitoring in general, additional information can be gathered by using the Level Two procedure. For those ranchers or operators that are faced with particularly sensitive or controversial issues or for the most ambitious resource managers, the Level Three procedure may be appropriate. In this document, we hope to provide resource managers with guidelines to determine what needs to be monitored, where to focus efforts, and how to most effectively get the best information for the time invested. In taking this approach, we also emphasize our belief that a single, “cookbook” approach to monitoring is not appropriate or efficient for New Mexico rangelands.

We also need to emphasize that this document and the methodologies contained herein are not designed nor intended to replace existing monitoring programs conducted by Federal land management agencies. Beginning a new monitoring program using new methodologies cannot adequately substitute for data that have been collected over long periods of time. Nor is the information provided in this document intended to suggest that the Federal land management agencies turn over their monitoring responsibilities to ranchers or natural resource managers. This document is designed to help ranchers gather their own data, for their own use, to supplement the information that the agencies may or may not be collecting.

Why Monitor

Livestock producers in New Mexico are increasingly being called upon to describe and document the condition of their rangelands. Most often, this request is made of producers who hold public land grazing permits. However, as regulatory vehicles such as the Endangered Species Act (ESA) and Clean Water Act (CWA) become more widely implemented, we predict that documenting rangeland condition even on private lands will be important.

The most effective means to document rangeland condition and trend is to adopt a monitoring program. The idea of rancher monitoring is not new. But as natural resource issues become more contentious, there has been renewed interest in and demand for monitoring programs for ranchers. In addition, the ranchers’ role will become more important because the public’s perception of livestock grazing on public land is changing. Also, increasingly, management agencies do not have the time or personnel to conduct their existing monitoring programs. Beyond being a good idea for defensive reasons, rangeland monitoring programs can serve many purposes including:

- determining the effectiveness of management practices
- determining if forage supply and demand are in balance
- documenting the effect of livestock grazing on natural resources

- documenting effectiveness of movement toward desired condition
- documenting reasons for range condition
- gaining a better understanding of resources and their management
- using the information gathered to provide for adaptive management strategies

What to Monitor

Determining *what* and *where* to monitor are probably the most time-consuming components of developing any rangeland monitoring program. These also are, perhaps, the most important aspects of developing a new monitoring program. Taking the time to thoroughly consider these points will pay dividends later by ensuring that the most pertinent things are monitored and that time is most efficiently allocated. Critical issues to consider include potential endangered, threatened, or candidate species; sensitive areas; Areas of Critical Environmental Concern (ACEC); riparian or wetland areas; erosion or pollution source areas; and areas that are subject to public access. Because these areas often occupy a small proportion of a pasture, ranch or allotment, the merit of devoting a disproportionate amount of effort toward monitoring them needs to be weighed cautiously. Certain interest groups and agencies will advocate focusing monitoring efforts in sensitive areas or comparing sensitive areas to less sensitive areas. However, focusing on sensitive areas may detract from an overall monitoring program designed to address resource concerns over a much larger area. We recommend that ranchers carefully consider estimated time investment plan accordingly.

Where to Monitor

Although sensitive areas should be considered when developing a monitoring program, areas that represent the bulk of a pasture, ranch or allotment should be included. Monitoring sites should not be located near livestock water sources, salt placements, roads, or livestock trails. If available, historic agency transect and cluster locations need to be evaluated for their potential as current monitoring sites. In this publication, we will refer to such sites as *key areas*. However, just because they were key areas historically does not mean they are key areas currently. Water placement, fence and road locations may have changed livestock distribution to make the historic sites poor locations for current monitoring efforts. It should be noted that nobody knows and understands a ranch better than the rancher and his/her experience should weigh heavily in the monitoring site selection process.

The question always arises, How many monitoring sites should I have on my ranch? Unfortunately, there are no universal guidelines to determine how many monitoring sites a ranch should have. Differences in ranch size, pasture size and site heterogeneity combine to make strict guidelines impossible. However, we do recommend that you have at least one monitoring site for each range site or vegetation type on each ranch. In a perfect world, ranchers would have one monitoring site for each range site or vegetation site within each pasture. In determining where and how many monitoring sites to establish, we suggest that, at least starting out, you plan on spending no more than two to three days each year monitoring your ranch. As the rancher becomes more comfortable with the monitoring program and procedures, this time investment can be increased.

When to Monitor

When should I monitor? is another frequently asked question as ranchers a new monitoring program. If limited time can be devoted to the new monitoring program, ranchers should monitor at the end of the growing season in the fall. If time permits, consider monitoring just before spring greenup. At the very least, each monitoring site should be visited once each year.

LEVEL ONE MONITORING

Range

1. Fixed photo points
2. Record precipitation

Equipment Needed:
USGS topographic map or aerial photo
Camera
Steel t-post
Hammer
Compass (optional handheld GPS unit)
Four one-foot long rebar or angle iron post
Dry erasable marker board
Erasable felt-tip pen
Two 6-foot long folding carpenter rulers
Three-ring binder
Clear plastic photo storage sheets
Range monitoring data sheet (Appendix A)
Precipitation data sheet (Appendix B)
Rain gauge
Approximately 1 tablespoon oil

Riparian

1. Fixed photo points
2. Record precipitation
3. Record flow events

Equipment Needed:
Same as equipment for Level One Range Monitoring *plus* yardstick or range pole
Level One Riparian Monitoring Data Sheet (Appendix C)

Erosion and Water Quality

1. Erosion and sediment delivery photo points

Equipment Needed:
Same as equipment for Level One Range and Riparian Monitoring *plus*
Erosion Photo Point Record Sheet (Appendix D)

Big Game

1. Track count survey

Equipment Needed:
Data sheets
Device for track removal (broom, tire drag etc.)
Track identification book (optional)
Track Count Survey Sheet (Appendix E)
Track Count Survey Summary Sheet (Appendix F)

Range Monitoring – Level One

Installing Fixed Photo Points

We recommend taking two photographs at each monitoring site – one landscape-level photo point and one ground-level photo point. Photographs should be taken at the end of the growing season. Taking the photograph on the same day every year is not necessary but do try to match pictures with the same plant growth stage each year.

The landscape-level photo point site should be marked with the steel t-post. Approximately 15 feet away from the T-post, prop up the erasable marker board so it can easily be seen in the photograph. Pasture name, photo point number and date should be recorded on the erasable marker board. Avoid facing the East or West to minimize variation due to sun position, place your back to the t-post and take the photograph. In addition, attempt to take subsequent photographs at the same time of day to avoid problems associated with shadows. Try to include in the photograph some landmark, such as a rock outcrop or hill, so the same photo can be taken each year. Bring past photographs along to try to duplicate the shot. If no landmarks are apparent, take a compass reading. On the Range Monitoring Data Sheet (Appendix A), thoroughly document and describe the photo point's location so someone else can find it if you are unavailable the next year. For example, record any landscape features evident at the photo point site. Handheld GPS units are very useful for locating a site. Also record the photo point site on the USGS topographic map or aerial photograph.

The ground-level photo point should be placed at least 10 feet away from the steel T-post in a location that is representative of the vegetation composition and ground cover. Hammer four, 1-foot rebar or angle iron posts into the ground to delineate a 3-foot square area to ensure the photograph is taken in the same location each year. Create a 3-foot square with the two folding carpenter rulers and place within the four short posts. To avoid casting a shadow on the plot, stand on the north or south side directly above the square created by the folding carpenter rulers and take the photograph. The erasable marker board should be used to indicate pasture name, photo point number and date and placed within the photograph but outside of the 3-foot square area.

After developing the photographs, place them in the clear photo storage sheets. Ground-level photos should be put in one clear sheet, while landscape-level photos should be put in a separate sheet so four years' worth of photos can be examined in one clear plastic sheet. Photos should be placed into a binder adjacent to data sheets.

Many ranchers also have historic photographs of the ranch or family photos taken at gatherings, which show landscape-level depictions of the rangeland. Copies of these also can be placed in the three-ring binder and may show changes in rangeland conditions, such as encroachment of piñon and juniper or changes in cottonwood densities in a riparian area. Short narrative descriptions may be included with these photos.

Recording Precipitation

Precipitation should be recorded following each rainfall event and may help explain yearly differences observed in photographs. It is important to record precipitation. If this information is not collected, agencies will refer to the closest weather station, which is often a long way away and may not accurately reflect precipitation on the ranch. Ideally, one rain gauge should be placed in each pasture with a small amount of oil in the gauge to prevent evaporation. Where possible, place rain gauges next to monitoring locations. Precipitation amounts should be recorded on the Precipitation Data Sheet (Appendix B). Use one sheet for each rain gauge.

Riparian Monitoring – Level One

Installing Fixed Photo Points

Establishing photo points for riparian areas involve virtually the same procedures as for installing photo points on upland rangeland. We recommend that one landscape-level photo and one ground-level photo also be taken. However, we also recommend adding an additional photograph to provide a visual reference for stream bank condition. As with upland monitoring locations, there is no rule of thumb to determine how many locations may be required.

Particular care should be exercised in choosing a landscape-level photograph location. Keep in mind that taking the photo in a northerly direction may not be possible due to stream orientation. Taking the photos at the same time of day each year can reduce variation due to sun position. Wherever possible, try to take advantage of higher ground to improve visibility and area covered by the photo. The stream reach to be photographed should be representative of the overall condition and shape of the stream and riparian area. One good rule of thumb is to try to include enough stream length to encompass at least two stream meanders (fig. 1). Several photo points may be necessary to achieve this. If the stream shape or size changes dramatically on your ranch, or if the composition or structure of the riparian vegetation changes, strongly consider adding additional monitoring locations. Photo point locations should be permanently marked with T-posts.

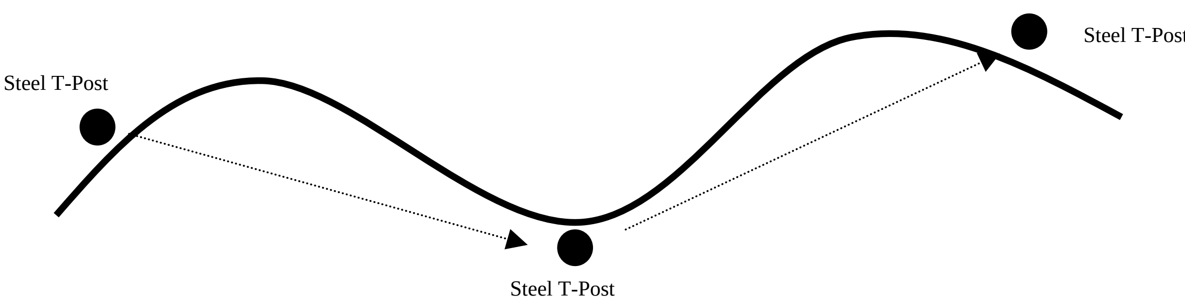


Figure 1. Establishing fixed-photo point locations for landscape-level riparian photographs.

The ground-level photograph should be taken in a similar fashion as described for upland range sites, using the folding carpenter rulers and four, 1-foot rebar or angle iron posts. This photo point should be placed within the riparian area and should encompass herbaceous riparian vegetation, such as sedges or rushes. If this is not possible, locate the ground-level photo in an herbaceous community closest to the stream.

The stream channel photo point should be located in the middle of the stream channel. This point may be placed immediately adjacent to the ground-level photo point to make them easier to locate. Take the photographs in a squatting position looking downstream. This will provide visual record for changes in stream bank condition.

Recording Precipitation

Follow the same procedures for recording precipitation on upland range. It is not necessary to add additional rain gauges unless other gauges are located a long way from the riparian area or you expect rainfall patterns to be different there from the other locations. Use one Precipitation Data Sheet for each rain gauge.

Recording Flow Events

It is a good idea to record periodic flow events, particularly in the case of high flows or flood events. This is true for both perennial streams (streams that flow year-round) and intermittent streams (streams that flow periodically). When destructive high flows occur, it would be worthwhile to record such disturbances with photos. The same photo points used for the annual monitoring can be used if they correspond to disturbed areas.

To record flow events resulting from snowmelt or precipitation, simply use a yardstick or range pole to measure the depth of the water in the middle of the channel. Also estimate, by pacing or measuring, the width of the flow and whether the flow accessed the floodplain. Record depth and width in the space provided on the Level One Riparian Monitoring Data Sheet (Appendix C).

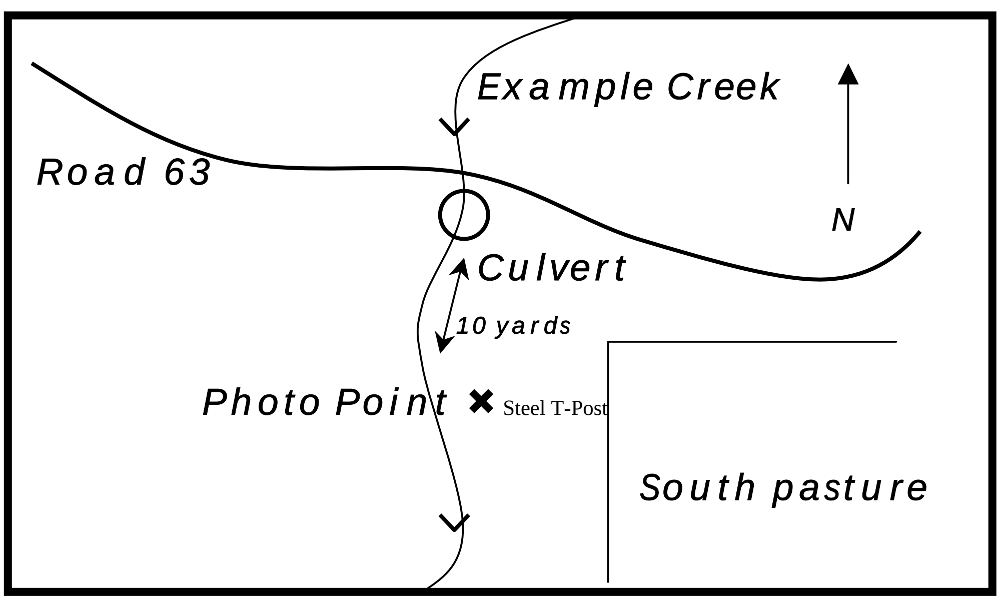
Erosion and Water Quality Monitoring – Level One

In New Mexico, delivery of sediment to streams is the most important rangeland water quality problem. Some sediment in streams may be important for carrying nutrition to aquatic ecosystems. Sediment is a problem, however, when management goals are to reduce stream water suspended sediment and stream bottom sediment deposits. Soil erosion, the source of sediment, also causes problems with ranch productivity and ranch sustainability by removing the topsoil needed for plant growth. Soil erosion is associated with rapid surface runoff. Areas without surface erosion are more likely to have fast water infiltration into the soil. Fast infiltration is best for retaining water on the ranch, and fast infiltration along with high water-holding capacity provide the best conditions for plant growth.

Most ranchers and land managers would like to know how land management practices on rangelands affect water quality in streams. It is, however, very difficult to clearly show cause and effect relationships between range management and water quality. Before embarking on a water quality monitoring program, ranchers should first determine if the monitoring objectives can be achieved with a photo monitoring program. Many of the land management practices that protect water quality also promote good range condition. Therefore, monitoring to document range condition will provide documentation on the natural resource conditions that affect water quality.

Level One erosion and water quality monitoring is designed to supplement range and riparian monitoring with photos of erosion problem areas that could cause water quality problems. Erosion site photo points document trends over time at key erosion areas. Photo points should be used to record erosion at sites, such as gullies, stream banks, culverts and road cuts. The procedure outlined for range photo points should be followed. Additionally, a pole for scale marked in 1-foot increments should be used with each erosion site photo. The Erosion Photo Point Record Sheet (Appendix D) includes details about the location of the sites and the photographs (Example 1). The format of the Erosion Photo Point Record Sheet is based on information from the University of California Cooperative Extension (Lewis et al., 1999), adapted for use on New Mexico rangelands. As with range and riparian monitoring, it is important that erosion site photo monitoring takes place at least once a year. It also is important that the conditions, such as photo point location, field of view, photo heading and lighting, are as similar as possible each time photos are taken.

Example 1. Erosion photo point location map.



Big Game Monitoring – Level One

In some areas of New Mexico, increasing populations of big game have created controversy and conflict concerning natural resource management on public and private lands. Information about big game population levels can be useful to help resolve many of these conflicts. Consultation between ranchers and state and/or federal agency personnel seldom involves quantitative and up-to date monitoring data regarding big game populations. This type of information would, in most cases, be helpful during such consultations. Population estimates and trend data may be used to help determine whether forage use concerns are the result of excess livestock and/or an increasing big game population. This information may influence whether subsequent management will involve stocking adjustments, increased game harvest or both. There also is a growing need to monitor and document big game population levels for wildlife damage and depredation purposes.

Fee hunting enterprises are a widespread method of generating income from big game for many private landowners. Monitoring big game populations on ranches is critical to the success of fee hunting enterprises. An effective monitoring program allows landowners to keep track of the big game resource on their property and make informed management decisions that will help ensure the success of their wildlife enterprise.

When starting a wildlife monitoring program, it is important to recognize the difference between a population estimate and population trend. A population estimate is the number of animals in a particular area. A population trend indicates whether the population is increasing, decreasing, or remaining stable and is most valuable when averaged over a several-year period. Level One big game monitoring provides reliable indicators of population trends for elk, deer and pronghorn.

Track Count Survey

Track counts are reliable, simple and economical. The underlying assumption is that the number of tracks that cross any given road will increase proportionally with an increase in population size. Conversely, as the population decreases, the numbers of tracks decrease. Because these are trend counts, the methodology must be consistent or the information obtained cannot be compared between years. You cannot change the route to be surveyed, time of day the survey is conducted or the season of year, if the information will be used to develop trend data.

If possible, conduct the surveys for two or three consecutive mornings. The more days surveyed, the more accurate the data will be. However, if you are unable to collect multiple days of data, then one survey is certainly better than no information at all. Track count surveys often provide the best information when conducted the morning after a fresh snowfall. Surveying during periods with snow cover increases the likelihood that every set of tracks that cross the road will be seen. In areas where snowfall is limited or nonexistent, the survey will be conducted on bare ground. When conducting a survey on bare ground, avoid times when the weather is bitterly cold and the roads are frozen hard.

The availability of roads on the ranch will dictate where survey routes are established. However, whenever possible try to establish a route within each habitat type on the ranch. Each route should be several miles in length if possible. The beginning and ending points of each route must have identifiable features so that no confusion arises over where each survey route begins or ends. The route(s) you select must be the same each year.

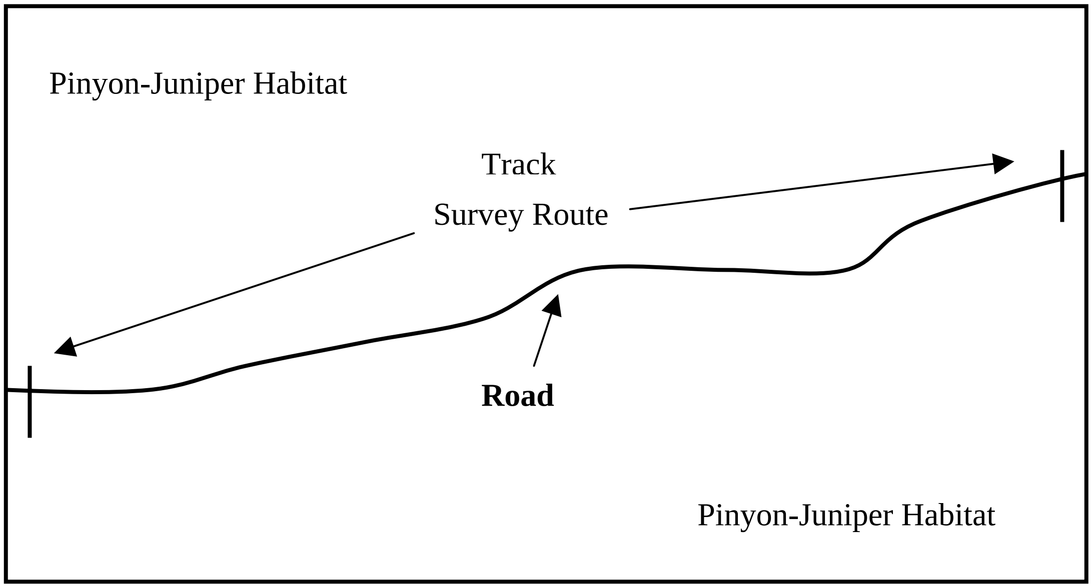


Figure 2. A survey route in a single habitat type.

Tracks must be cleared from the roads the evening before each survey is conducted. All old tracks should be brushed out so they will not be counted the following morning. This can be done easily by dragging any device that will lightly disturb the surface of the road behind the vehicle. One example is a tire drag made by bolting old car tires together until the desired length and width is achieved. A large tree limb that is several feet wide also could be used in a pinch. Extra work may be required on snow-covered roads to erase old tracks. This is particularly true if the snow freezes hard each night.

The track count survey should start at mid-morning, sometime around 9 a.m., in order to detect animal movement for the morning of the survey and from the night before. The route is most easily surveyed using an automobile, but a snowmobile, all terrain vehicle or even a horse can be used if necessary.

While traveling the route, count the sets of tracks that cross the survey route. Do not count each individual track made by an animal, but rather each line of tracks that cross the road. Observers should be familiar with wildlife tracks to minimize mistakes. Elk, deer or pronghorn that enter and leave the road without crossing it are not counted. Animals that walk down the road but do not cross it until they are beyond the designated route segment are not counted. Animals that cross the route on more than one occasion will be counted several times. This can lead to slightly inflated values. But, this should not present a problem since consistency from year to year is the goal for trend information.

In addition to the actual tracks observed, several other items must be recorded on the Track Count Sheet (Appendix E) on the day the survey is conducted. This will provide valuable information and can help explain any unusual findings that may be observed. A column is provided for route segments. These may represent 1-mile increments if the route is continuous, or the segment number if the route continues intermittently. Each time tracks are observed, record the segment in which they occur, as well as the number of sets observed.

A Track Route Information Sheet (Appendix F) also must be prepared as a permanent record of survey methodology. The "Location and Description of Route" section should be detailed enough so that the route can be surveyed even if permanent markers on the route are lost. A detailed description of the route is especially important if different individuals will be conducting subsequent surveys. Details should include permanent landmarks that are natural and man-made, including road crossings, prominent trees and rock outcroppings. Each year, record the results of each of the surveys and calculate the average number of tracks observed.

LEVEL TWO MONITORING

Level Two monitoring includes all Level One monitoring plus the procedures described below.

Range

1. Record in and out dates and number, kind and class of animals
2. Visual appraisal of use and production
3. Remarks and incidences record

Equipment Needed:
Range Monitoring Data Sheet (Appendix A)
Folding ruler

Riparian

1. Cross section transects
2. Greenline transects
3. Woody species regeneration

Equipment Needed:
Cross Section Data Sheet (Appendix G)
Greenline Transect Data Sheet (Appendix H)
Woody Species Status Data Sheet (Appendix I)
Folding carpenter ruler
Steel T-posts

Erosion and Water Quality

1. Erosion and sediment delivery monitoring

Equipment Needed:
Erosion and Sediment Delivery Monitoring Worksheet (Appendix J)
Folding carpenter ruler
Measuring tape

Big Game

1. Spotlight surveys

Equipment Needed:
Vehicle
Spot light
Binoculars
Spotlight Survey Count Sheet (Appendix K)
Spotlight Survey Count Summary Sheet (Appendix L)

Range Monitoring – Level Two

Record In and Out Dates and Number, Kind and Class of Animals

It is important to keep track of this information for your records, particularly if you hold a public land grazing permit. The number, kind and class of animals should be recorded for each pasture every year to complement photographs and information about vegetation. Refer to the Range Monitoring Data Sheet (Appendix A) to record this information.

Visual Appraisal of Use and Production

Visual appraisal of production and use is an efficient means to check whether forage supply and demand are in balance. Stocking rate adjustments can be made if these appraisals indicate that livestock numbers should be adjusted up or down. If you have a public land grazing permit, you should to involve your range conservationist. This will ensure agreement with regard to your appraisal of production and use. Production and use scoring can be conducted at the same time photos are taken. Refer to tables one and two for a description of production and use categories.

More quantitative information can easily be gathered for production and use by taking a few stubble-height measurements. Once a visual appraisal of use is made, determine the average height of approximately 10 ungrazed plants of the one or two key species present on the site. This average can be recorded in the relative use column on the Range Monitoring Data Sheet. For culmless (plants with small or few seed heads) plant species, such as blue grama or Kentucky bluegrass, measure average *leaf* height or length. For culm (plants with larger, longer or more numerous seed heads) species, such as black grama, side oats grama or little bluestem, measure the seed head's average height. Similarly, following a visual appraisal of use, an average height of 10 grazed plants of the same key species can be recorded in the use column on the Range Monitoring Data Sheet.

Table 1. Description of production categories.

Production Scores		
1.	Extreme Drought	No growth occurred this year.
2.	Below-Average Production	Production appears less than most years.
3.	Average Production	Production is comparable to most years.
4.	Above-Average Production	Production is greater than most years.
5.	Extremely Wet Year	Excellent growing season. Range production is at maximum potential.

Table 2. Description of use categories.

Use Scores and Appearance		
1.	None to Slight	No visible use on key species.[1]
2.	Light	Only preferred areas and key forage species are grazed. Much of the highly preferred plants are ungrazed.
3.	Moderate	Key areas are grazed uniformly. Key species supply the bulk of the grazing load.
4.	Heavy	Key species are grazed closely. Low-value plants are used moderately.
5.	Severe	Pasture appears mowed. Low-value plants carry the grazing load.

[1.] Key species may vary depending on range sites and objectives. Key species typically used for monitoring use are preferred forage species.

Remarks and Incidences Record

It is important to record any events that may help to explain the appearance of the range. For example, drought conditions, an insect outbreak, a fire or wildlife distribution concern can be recorded as a reminder of events that affect the appearance or condition of your range.

Riparian Monitoring – Level Two

Cross-Section Transects

Establishing cross-section transects is an efficient and effective method to track how riparian areas become wider or narrower or how the vegetation communities change. Transects can be placed adjacent to photo points. While there is no magic number of transects that need to be established, the more you have, the more reliable the information you will collect. Consider using no fewer than three transects for each monitoring location. The number of monitoring locations depends on how much stream length and riparian area are present on your ranch, as well as how similar they are.

Once a cross section site has been located, one steel T-post should be located in an upland area on each side of the stream. These T-posts also can be used as the photo point locations if possible. A line drawn between the two T-posts should be perpendicular to the stream. Locating the starting and ending points of the cross-section transects in upland areas ensures that they do not get washed out by floods and allows for a widening riparian area. Always starting on the right side of the stream (looking downstream) will ensure that the data are collected the same way each year. Begin pacing from the T-post and count the number of paces you take within the upland area. Record on the Cross Section Data Sheet (Appendix G) the number of paces and the dominant vegetation species present. As a new vegetation type (i.e., riparian vegetation) is encountered, record the number of paces and list the dominant species. Keep in mind that you may encounter several different community types in the riparian area and these should be recorded separately for accurate tracking of yearly changes. As you cross the stream channel, record its width. Instead of recording vegetation species, record substrate type. Examples of substrate type may be gravel bar with no vegetation, main or active channel with sandy bottom or bedrock. Continue pacing and recording on the opposite side of the stream to the ending T-post. A small area also is provided on the Cross Section Data Sheet (Appendix G) to sketch the shape and depth of the stream banks. The method and format of the Cross Section Data Sheet is based on information from the USDA Rocky Mountain Research Station (Winward, 2000), adapted for use by ranchers on New Mexico rangelands.

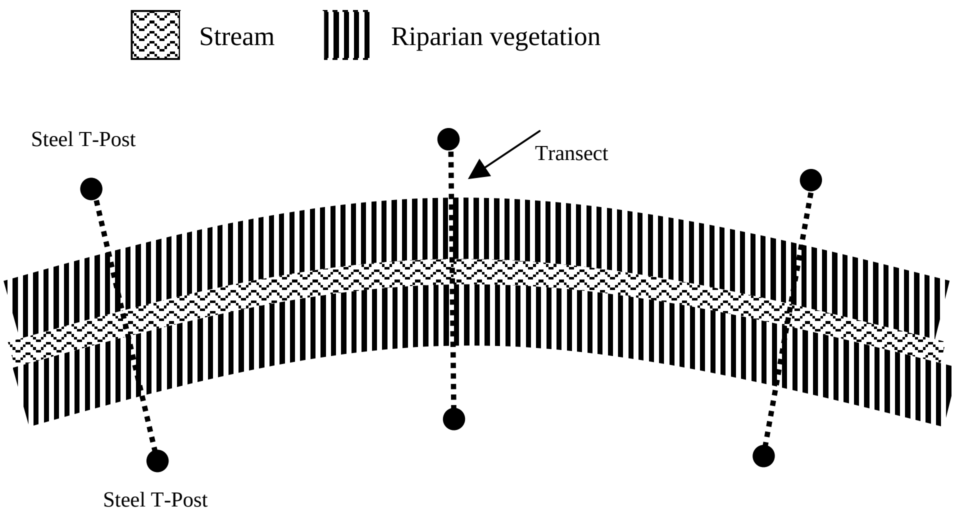


Figure 3. Locating cross-section transects for Level Two riparian monitoring.

Example 2. Data sheet for recording cross-section transect data:

Sketch (optional):

Community Type (include dominant species and gravel bars, bare ground, etc.)	**Total Steps**	**Community Type %[1]**
Piñon-Juniper, blue grama	*30*	*57.7*
Cottonwood, rabbit brush	*12*	*23*
Willow	*2*	*3.8*
Gravel bar	*3*	*5.7*
Main channel	*5*	*9.6*
Total	*52*	

[1.]Community type % is calculated by dividing steps taken in each community type by the total number of steps taken.

Greenline Transects

The greenline is defined as the first line of vegetation adjacent to the stream channel. Greenline transects help quantify vegetation and other structures that anchor and armor streambanks. These transects are very responsive to annual changes in streambank characteristics. The greenline transect is designed to measure riparian vegetation. However, there are riparian areas in New Mexico that have eroded downward such that the channel is well below the top of the stream bank and the greenline is all upland vegetation. In this case, the greenline transect should be run on the upland vegetation.

Once again, there is no standard for the length of a greenline transect. One rule of thumb is for the greenline transect to encompass at least two meanders along the stream. A greenline transect should be run on both sides of the stream for that distance. It is a good idea to start on the right side (looking downstream). Run the transect, and then run the transect on the other side coming back the opposite direction. The same pacing procedure should be used for the greenline transect as for the cross-section transect. Use the Greenline Data Sheet (Appendix H) to record each vegetation type or group of species that occurs along the greenline for at least one pace. The method and format of the Greenline Data Sheet is based on information from the USDA Rocky Mountain Research Station (Winward, 2000), adapted for use by ranchers on New Mexico rangelands. Large boulders, logs that are securely anchored in the bank, or rock outcrops should be paced and recorded similarly. If a boulder or vegetation type does not occur for a distance of at least one pace, it should not be recorded separately. The starting and ending points for each greenline transect should be permanently marked. Keep in mind that the marker should be placed far enough from the stream to ensure that it does not get washed away in a flood. A thorough description of the starting and ending points next to the stream should be recorded, so it will be easier to locate them in subsequent years.

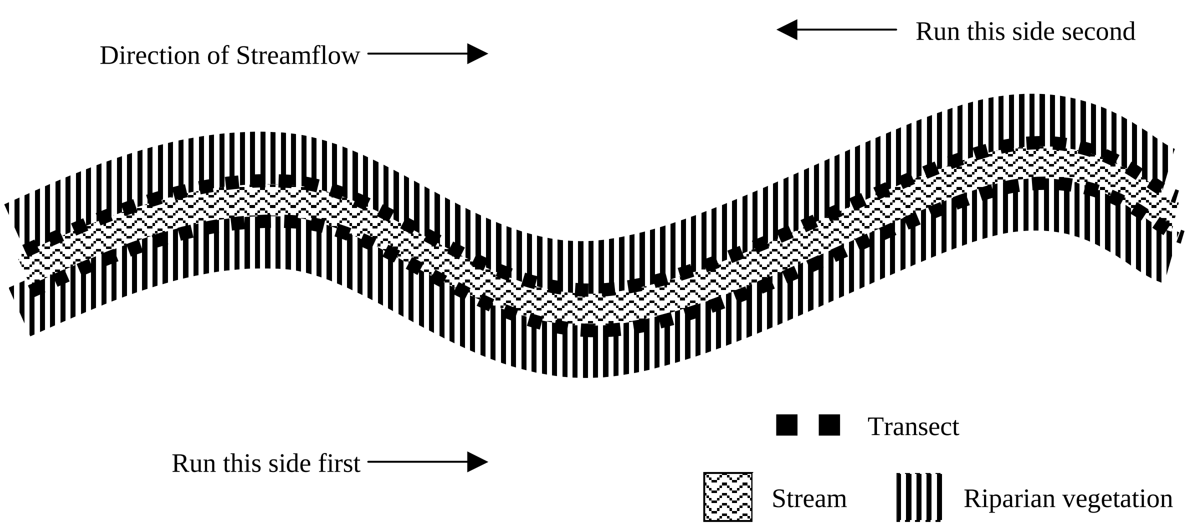


Figure 4. Locating greenline transects for Level Two riparian monitoring.

Example 3. Data sheet for recording greenline transect data:

Community Type (include dominant species and logs, boulders, etc.)	**Right Side of Stream**			**Left Side of Stream**	
	# Steps	**Community Type %**		**# Steps**	**Community Type %**
willow	*10*	*41.6*			
Sedges, rushes	*3*	*12.5*			
Rock cliff	*6*	*25*			
willow	*5*	*20.8*			
Total	*24*				

Status of Woody Riparian Species

Not all riparian areas support woody vegetation in New Mexico. However, where they are native, they serve numerous important functions and should be considered in a Level Two monitoring program. The woody species transect follows the same path as the greenline transect. The only difference is that the woody species transect is a belt transect. Unfold the carpenter ruler and hold it in the center, so your hand stays directly over the greenline. If the stream is less than 3 feet wide, adjust the position of the carpenter ruler so the left edge is directly over the center of the stream to avoid double sampling. Walk downstream and record the number, age class, and species on the data sheet.

The Woody Species Data Sheet (Appendix I) provides columns for age class and whether the plant is browsed or unbrowsed. The method and format of the Woody Species Data Sheet is based on information from the USDA Rocky Mountain Research Station (Winward, 2000), adapted for use by ranchers on New Mexico rangelands. Table 3 provides guidelines for placing multiple-stemmed or clumped species into age-classes. For those woody riparian plants that are not multiple-stemmed, you'll need to make a judgement call. It is a good idea for ranchers who hold public land grazing permits to discuss these judgements with range conservationists so there is agreement about how the plant will be categorized.

Table 3. Guidelines for estimating age of multiple-stemmed, woody species.

Number of Stems at Ground Level	Age Class
1	Sprout
2 – 10	Young
> 10, > ½ stems alive	Mature
> 10, < ½ stems alive	Decadent
0 stems alive	Dead

Erosion and Water Quality Monitoring – Level Two

While ranchers may face many different water quality issues, sediment in streams is the most important on New Mexico rangelands. Erosion that leads to stream sedimentation also can be a serious problem for ranch productivity and sustainability. The Level Two Water Quality section provides techniques to estimate the amount of eroded material that could be delivered to streams and information about prioritizing erosion sites for monitoring and management.

Erosion and Sediment Delivery Monitoring

Variability in sediment delivery to streams over space and time often makes it more effective to monitor sediment sources than stream sediment. Very detailed studies are required to show sediment sources on the watershed that contribute to sediment at one location in a stream. Monitoring erosion and evaluating the amount of sediment that is delivered from erosion hot spots provides valuable information about the sediment sources. Inventories of erosion hot spots also provide a starting point for fixing erosion problems that impair ranch productivity and sustainability.

The Erosion and Sediment Delivery Monitoring Worksheet (Appendix J) provides a framework for evaluating erosion problem areas and prioritizing sites for remediation. The worksheet's objectives include: being easy to implement for public and private ranchers, providing data to address water quality regulations, and using terminology that prepares landowners to interact with agencies, such as the Natural Resources Conservation Service (NRCS), for help in designing and implementing sediment delivery controls. The method and format of the Erosion and Sediment Delivery Monitoring Worksheet is based on information from the University of California Cooperative Extension (Lewis et al., 1999), adapted for use on New Mexico rangelands.

The erosion site photo points discussed in Water Quality Monitoring Level One are an important complement to the Erosion and Sediment Delivery Monitoring Worksheet. Level One photo point monitoring for significant erosion areas should begin immediately. Level Two monitoring with the worksheet need not occur all at once. Fill out the worksheet for a few sites at a time until the set of monitoring data for all important erosion areas is complete.

The Erosion and Sediment Delivery Monitoring Worksheet (Appendix J) contains all the information needed to monitor erosion sites, evaluate the amount of sediment that might be delivered to stream channels, and prioritize the sites for monitoring and management. A separate copy of the worksheet should be completed for each significant erosion site, noting a site number and description on the worksheet.

Example 4. Erosion and sediment delivery monitoring worksheet.

SITE # : __*1*___ **LOCATION DESCRIPTION:** _*Culvert under Rd. 63 by Corner of South Pasture*_

SITE SELECTION CRITERIA (select Yes or No)

Y / N Deliverable to surface water? Y / N Responsive to mitigation?

Y / N Management caused?

SEDIMENT VOLUME (yards^3)

Eroded volume: H=__*1*____ L = __*10*_____ W = __*1*_____ Volume (H*L*W)=__*3*__

Potential volume: H=___*1*____ L = __*20*_____ W = __*1*_____ Volume (H*L*W)=__*40*

% Deliverable (select one) ____ 0-30% ____ 30-70% __✓__ 70-100%

UNSTABLE AREAS (for sediment source sites without a "Y" for all three site selection criteria)

☐ Photo monitoring ☐ No monitoring

LOCATION CATEGORY (select one)

☑ Road ☐ Riparian ☐ Hillslope / uplands

EROSION PROCESS (select one)

☐ Streambank erosion ☐ Sheet erosion ☐ Rill erosion ☑ Gully erosion

INFLUENCE (select all that apply)

☑ Road drainage design ☐ Road fill failure ☐ Historical ☐ Livestock grazing

☑ Culvert design ☐ Road cut failure ☐ Natural ☐ Livestock trail

☐ Stream channelization ☐ Dam or spillway ☐ Wildlife grazing ☐ Crop agriculture

☐ Shrub encroachment ☐ Woodland encroachment ☐ Other ___________________

POTENTIAL CONTROL MEASURE (select all that apply)

☑ Road improvement ☑ Channel grade stabilization ☐ Grazing management

☐ Surface treatment ☐ Streambank protection ☑ Monitoring

PRIORITIZATION (See table below for points)

	Description	Points
Assistance needed:	*Some – Culvert Design*	*2*
Estimated time:	*One day*	*3*
Estimated cost:	*\$100.^{00} - \$1,000.^{00}*	3
Potential volume: (from SEDIMENT VOLUME above)	*40 yds ^{3}*	*2*
% Deliverable: (from SEDIMENT VOLUME above)	*70 – 100 %*	*8*
	TOTAL PRIORITY SCORE =	*18*

Prioritization Table

Assistance Needed	Pts.	Time	Pts.	Costs	Pts.	Potential Volume	Pts.	%Deliverable	Pts.
Technical	1	> Week	1	> \$10,000	1	10-100 yd^3	2	0-30%	2
Some	2	1 Week	2	\$1000-10,000	2	100-200 yd^3	4	30-70%	5
Minimal	3	1 Day	3	\$100-1000	3	200-500 yd^3	6	70-100%	8
None	4	< Day	4	<\$100	4	>500 yd^3	8		

The three “Site Selection” criteria help ranchers select sites to be monitored. Sites with erosion that is “Deliverable to surface water” should be identified based on the understanding or estimation of where water flows on the ranch. Sites that predominately have natural sediment delivery should be distinguished from those that predominately have “Management caused” erosion. If a site requires a large and costly effort to make any effective change in erosion, or if no mitigation would be feasible, the site is not “Responsive to mitigation.” If all three criteria are not met for a site, sediment delivery cannot be controlled. Such sites should still be monitored with photo points as recorded in the “Unstable Areas” section of the worksheet.

To measure eroding areas for the “Sediment Volume” section of the worksheet, pace off or measure the eroding feature, estimating the eroded volume and the potential volume that could be eroded. Use the best information available regarding surface hydrology to estimate the percentage deliverable for each site, with erosion in channels having the highest percentage deliverable and erosion from uplands having a lower percentage deliverable. Sites without surface vegetation or litter will have a higher percentage deliverable than bare sites. As with other types of monitoring, the absolute values are less important than having a consistent approach to monitoring all sites over time.

The “Location Category” and “Erosion Process” sections of the worksheet allow ranchers to describe erosion sites in terms that can be used in discussions with agencies like the NRCS to establish remediation projects. The “Influence” section allows the ranchers to use knowledge of history, natural conditions and management practices to evaluate the erosion causes. The “Potential Control Measure” section gives a starting point for ways to mitigate the erosion and sediment delivery problem site.

Going through the worksheet steps and assigning a “Total Priority Score” to each site is most useful for comparing different sites on a ranch and deciding which sites should be monitored with photo points and which should be targeted for remediation. The worksheet also provides important supporting data to accompany photo point monitoring.

Big Game Monitoring – Level Two

Spotlight Survey Method

Spotlight surveys can provide overall population estimates as well as population trends for elk, deer and pronghorn. The spotlight survey can be conducted instead of, or in addition to, track count surveys. The same basic principles for consistency apply to spotlight surveys as were outlined for the track count survey.

Spotlight surveys are a more advanced monitoring method than track counts and, consequently, provide a wider range of useful data. Sex ratios and some limited age ratio information can be determined at the same time as the population estimates. The quality of the male population also can be evaluated for trophy hunting.

1. As discussed earlier in the "Track Count Survey Method," sample routes should be established in the different habitats on the ranch. If you have two distinct habitat types, such as open grassland and pinyon-juniper woodland, then a spotlight survey route should be located in both habitats (fig. 5). But as previously mentioned, this will be dictated largely by the availability of roads on the ranch.

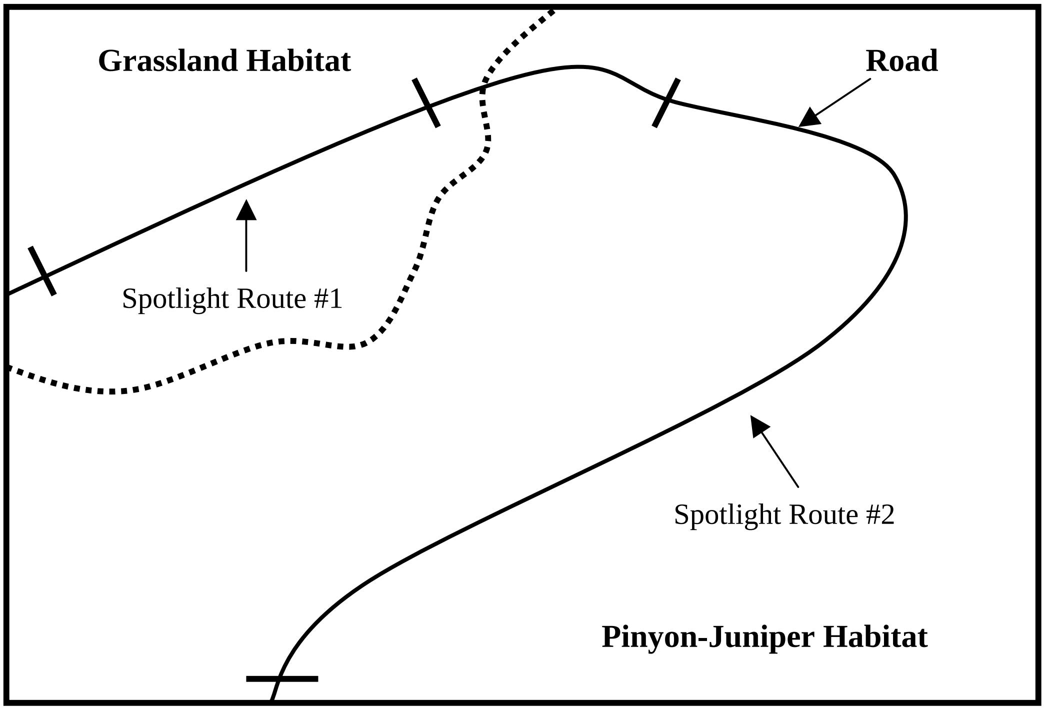


Figure 5. Establishment of survey routes in two habitat types.

2. Spotlight routes must be several miles in length. There is no fixed length for survey routes, but the more miles you survey the more representative the information will be. The routes can be segmented and do not have to be successive. But remember to count only the animals you observe within the designated route.

3. In order to make a population estimate, the number of acres surveyed must be calculated. If survey routes are established in different habitat types, then the amount of area surveyed within each habitat should be calculated separately. This allows you to calculate an animal density for each habitat type. Estimate the total acreage for each habitat type that occurs on your ranch. Once the number of animals per acre has been determined for each habitat type, apply these densities to habitat acreages estimated for the ranch. This allows you to estimate the number of animals that occur in the different habitat types. Then combine all of the estimates for the different habitats to get a single population total for the entire ranch.

4. To determine the number of acres surveyed along the route, the distances that you can see to the right and left of the road must be measured. The first time that the spotlight survey is conducted, stop at 1/10-mile intervals along the road and estimate the

distance you can see to the left and to the right with a spotlight and without the aid of binoculars (fig. 6). Record this information along with the total length of the survey route. These distance estimates only need to be made the first time the sample routes are driven. It is not necessary to repeat them for further surveys, unless something occurs that significantly changes the distance you can see over a large area. Examples of such events include a large fire, timber harvest or some type of brush treatment.

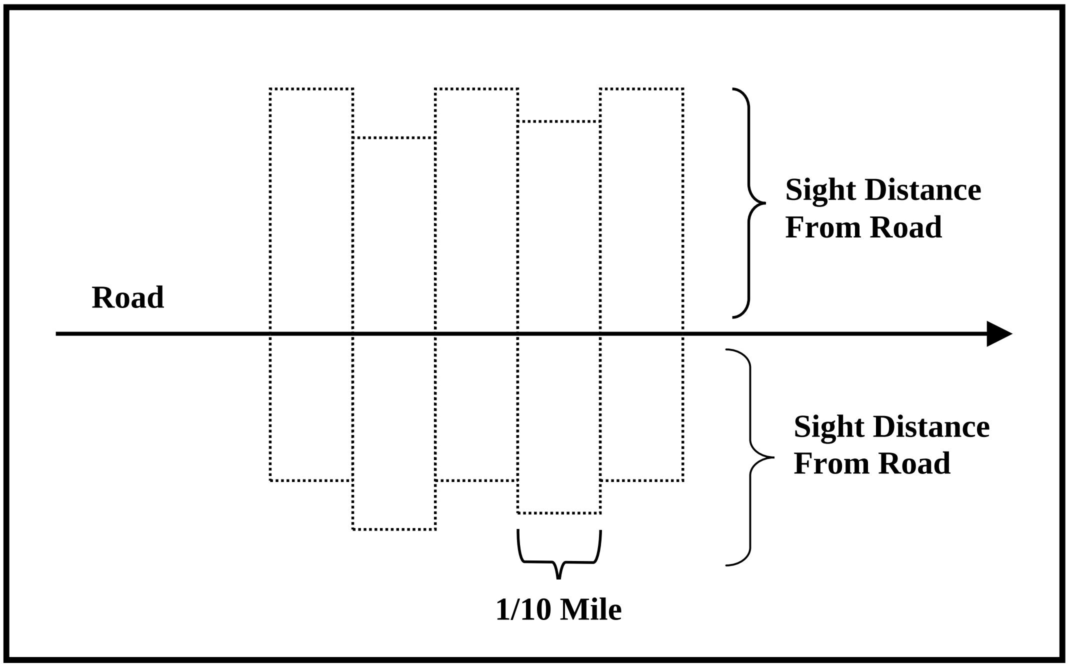


Figure 6. Determining number of acres surveyed along spotlight route.

5. To survey for game management:
   - Run surveys in mid-August (pre hunt) to estimate sex and age ratios as well as fawning/calving rates. Fawns and calves are moving with adults, and adult males are easily distinguished from adult females at this time.
   - Run surveys in December-January (post hunt) to obtain adult and fawn/calf survival. Population trend estimates can be made for the December-January surveys as well as the mid-August surveys, once multiple years of data have been collected.

6. To survey for depredation:
   - Run surveys in spring (mid-April to May), if you have depredation problems during early greenup.
   - Run surveys just prior to hunts if you have depredation problems in the fall/winter.
   - Rerun surveys in winter (December-January) after all hunts are completed to correlate a decrease in damage to population reductions.

7. Do not conduct surveys when a storm minimizes visibility or during weather extreme conditions.

8. Travel at a fairly slow speed that maximizes sighting ability and maintain a consistent speed throughout the survey.

9. Conduct multiple surveys on successive days if possible. However, if only one survey can be conducted during a sample period, don't be discouraged from proceeding.

10. Each survey should be started roughly at the same time (shortly after dark) for consistency.

11. Shining and spotting can be conducted a number of ways. Two people can ride in the bed of a pickup, each one responsible for shinning and spotting on a particular side of the road. Or one person can sit in the passenger side of the truck and shine only on the passenger side of the road. However, if this method is employed, only half as much area is being survey compared to the example in fig. 5. In this case, the area sampled would only be calculated for the passenger side of the road.

12. Count only the elk, deer and/or pronghorn you see, while you are within the route segment. Try not to count animals twice and do not use binoculars to increase counts. However, you may use binoculars to determine sex and age (fawn, sub adult and adult) of animals spotted with the unaided eye.

13. Record the number of cows (does), bulls (bucks), calves (fawns) and unknowns along with weather and general information (Appendices K and L). When elk, deer or pronghorn are sighted but sex cannot be determined, record the animals as unknowns.

14. In areas of low game concentrations, multiple survey efforts during a brief time period may be necessary to obtain meaningful data.

15. Remember all methodologies must be consistent from year to year.

16. Make a courtesy call to the New Mexico Department of Game and Fish and the county sheriff's office informing them that you will be conducting a spotlight survey on your ranch. This is an effective public relations action that will prevent a law enforcement officer from having to make an unnecessary late night trip to the field to investigate a suspected poacher. It is imperative that you understand the law regarding spotlighting, regardless of how honest your intentions may be. According to the New Mexico Department of Game and Fish, it is illegal "to shine spotlights or other artificial lights into areas where big game or livestock might be, if persons using the light have in their possession any firearms or implement capable of killing big game or livestock."

Therefore, when conducting a spotlight survey be certain to leave your firearms or any other device that may be construed as a weapon at home.

Example 5. Elk spotlight survey data collected during 1996 and 1997.

Date	Cows	Bulls	Calves	Unknown	Total
Aug. 1, 1996	2	1	1	0	4
Aug. 2, 1996	1	2	1	2	6
Aug. 3, 1996	3	1	1	1	6
Aug. 4, 1996	2	1	2	1	6
Average for Year	**2**	**1.25**	**1.25**	**1**	**5.5**

Date	Cows	Bulls	Calves	Unknown	Total
Aug. 3, 1997	4	1	2	1	8
Aug. 4, 1997	3	1	1	1	6
Aug. 5, 1997	3	1	2	1	7
Aug. 7, 1997	3	0	1	1	5
Average for Year	**3.25**	**.75**	**1.5**	**1**	**6.5**
% Change from 1996	**+62.5**	**-40**	**+20**	**0**	**+18.2**

On the spotlight survey conducted in 1996, an average of 5.5 elk were observed for the four days. In 1997, the spotlight survey resulted in an average of 6.5 elk observed for the four days.

Estimating Population Trend from Example 5:

- The information indicates that the herd increased 18.2 percent (((6.5-5.5)÷5.5) x 100) from 1996 to 1997. The number of cows observed increased 62.5 percent; the number of bulls observed decreased 40 percent; the number of calves increased 20 percent; and unknowns did not change.

- The bull/cow ratios in 1996 and 1997 were 1:1.6 and 1:4.3, respectively, (divide 2 by 1.25 to get the number of cows per bull with the 1996 data).
- The calf/cow ratios in 1996 and 1997 were 1:1.6 and 1:2.2, respectively.

Calculating a Population Density Estimate for 1997 from Example 5:

- To determine the total area surveyed use the following formula:

  $AS = SQ \div C$

Where:

AS = Acres surveyed
SQ = (L+R) x D
C = 43,560 $feet^2$/acre
L = average distance in feet seen on the left side of the road
R = average distance in feet seen on the right side of the road
D = total distance of route in feet

- For this example, assume you had an 8-mile transect route located in a single habitat type (80, 1/10-mile intervals). By summing the 80 distances recorded on the left and dividing by 80, you would have the average distance seen on the left side of the survey route. Do the same procedure for the right side of the survey route to obtain an average for this side. The 8 mile transect route would be 42,240 feet in length (8-miles x 5,280 feet/mile = 42,240 feet). Assume you estimated that you could see an average of 240 feet on the left and 180 feet on the right of the transect route.

- Use the above formula to determine the total area surveyed:
  (240 feet on left side of road + 180 feet on right side of road) x 42,240 feet = 17,740,800 $feet^2$. Therefore, 17,740,800 $feet^2 \div$ 43,560 $feet^2$/acre = 407 acres surveyed.

- As a result, in 1997 you observed 6.5 elk in a 407-acre sampling area.

- That translates to an elk density of 6.5 elk/407 acres or 0.02 elk/acre (divide 6.5 by 407 to get 0.02).

- Another way to describe the observed density is to divide 1 by 0.02. This gives a density of 1 elk/50 acres.

- If your ranch had a total of 7,680 acres of one habitat type (12 sections), then you can estimate the total number of elk at 154 elk in 1997 (0.02 elk/acre x 7,680 acres = 154).

LEVEL THREE MONITORING

Level three monitoring includes all Level One and Level Two monitoring plus the procedures described below.

Range

1. Herbaceous production
2. Plant species density
3. Plant species cover
4. Ground cover
5. Vegetative composition
6. Plant species frequency

Reference Material:
Probability Table (Appendix M)
Sample Field Sheet (Appendix N)

Riparian

1. Width to depth ratios
2. Lateral stability
3. Livestock use of woody riparian vegetation
4. Water quality monitoring

Reference Material:
See acknowledgements

Erosion and Water Quality

1. Stream Flow and Stream Sediment Monitoring
2. Erosion, Sediment Yield, and Sediment Load
3. Instream Water Quality Monitoring
4. Land Use and Water Quality Cause and Effect Studies

Equipment Needed:
Water sample bottles and lids
Indelible marking pen
Record of Flow and Water Quality Samples (Appendix O)

Big Game

1. Pellet group count method

Equipment Needed:
18 to 24-inch rebar stakes
1.5-inch diameter metal key ring
11-foot, 9-inch long dog chain
Orange, red or yellow spray paint
Pellet Group Count Sheet (Appendix P)
Pellet Group Count Summary (Appendix Q)

LEVEL THREE MONITORING

Level Three monitoring includes Level One and Level Two monitoring plus the procedures described below. In this section, we simply describe the types of information that can be collected for more advanced range, riparian, water quality, and wildlife monitoring. In our view, complicated monitoring programs are difficult to adopt, and the best monitoring programs are those that are simple and long-established. For those operators who feel a more advanced monitoring program needs to be implemented, we recommend that you consider enlisting the service of a range consultant.

Range Monitoring – Level Three

As you become more comfortable with range monitoring and make it part of your annual "routine," you may want to begin collecting more quantitative information. Keep in mind that collecting this information is more intensive and time-consuming. In addition, you may want to enlist the help of people who are familiar with vegetation sampling until you become proficient in plant identification and sampling protocol.

There are a wide variety of vegetation attributes that can be measured. Some of the more common quantitative measures are discussed below.

Herbaceous Production

Herbaceous production generally is expressed as lbs/ac. Although measuring herbaceous production can be very time-consuming and production is highly responsive to climatic fluctuations, it may be useful for establishing initial stocking rates on ranges where little or no historical survey information is available. Herbaceous production generally is measured at the end of the growing season. However, each species reaches its peak standing crop at a different time. This can be a significant problem in mixed plant communities.

Plant Species Density

Plant Density is the number of individual plants by species per unit area (i.e., number blue grama/square foot). Plant density describes the closeness of individual plants to one another. Measuring plant density can be useful for monitoring threatened or endangered species habitat, because the number of species per unit area is sampled. However, measuring plant density must only be used to compare similar growth forms (i.e. bunchgrass versus rhizomatous plants). In addition, in rhizomatous or stoloniferous plant communities, or in multi stemmed shrub communities, it often is difficult to count or distinguish individual plants.

Plant Species Cover

Cover is the percentage of ground surface covered by vegetation. Cover generally is expressed as a percentage. A variety of cover measurements can be taken and are discussed below.

Vegetative Cover

Total vegetation cover on a site. Vegetative cover measured in several ways, including foliar cover, canopy cover and basal cover.

Foliar Cover

Area of ground surface covered by the aerial portions of the plants. Small openings in the canopy are excluded.

Canopy Cover

Area of ground surface covered by the outermost perimeter of the plant foliage's natural spread. Small openings within the canopy are included and may exceed 100 percent.

Basal Cover

Ground surface area occupied by the plants' basal (ground) portions.

Ground Cover

Cover provided by a combination of plants, litter, rocks and gravel. Ground cover is the most often used cover measurement to determine a site's watershed stability. However, comparisons among sites are difficult, because of the different potentials associated with each range or ecological site. Basal cover can be calculated when ground cover information is obtained by simply excluding litter and rock.

Vegetative Composition

Vegetative composition, which must be calculated rather than directly collected in the field, is used extensively to evaluate range condition. Vegetative composition is the proportion of various plant species in relation to the total plant species of a given area. Vegetative composition may be expressed in a variety of terms, including relative cover, relative density and relative weight. Vegetation composition estimates can provide reliable, long-term range health information.

Plant Species Frequency

Frequency, which is merely the presence or absence of the species in the plot, is one of the easiest characteristics to measure. Frequency data depends on the size of the quadrat used. Ideally, quadrat size should sample the major plant species at 70 to 80% frequency. Frequency of a species depends on plant size, spatial distribution and density. Therefore, frequency data are site specific. At least one transect needs to be established at each range site. Remember that a range monitoring technique that emphasizes plant frequency will not provide a carrying capacity or a range condition classification. However, frequency can provide a statistically reliable method for evaluating range trend. This may be more important in the future as land management agencies move toward a focus on desired plant community and desired future condition.

New Mexico State University's Cooperative Extension Service has used frequency in range monitoring programs in the past. You may want to consider its merits for your range monitoring program. Permanent sampling locations for individual plots are not critical, but using transects that are as close as possible from one year to the next. Plot size depends on the vegetation to be sampled. A 10-by-16-inch plot may be used initially to evaluate whether a smaller or larger size is necessary. Both plant frequency and ground cover are measured with a quadrat that is moved at a one pace or two step interval along a transect. A handle on the plot frame provides for faster and easier sampling.

Frequency measures follow a binomial distribution, which means it is possible to determine whether differences in plant frequency are real or are due to sampling error. With binomial distribution, a table of confidence intervals for each frequency percentage for a given number of plots can be calculated. A 95 percent confidence interval table for the binomial distribution with 100 plots is given in Appendix M. For a plant species to show a significant change from one sampling date to another, the confidence intervals for the two frequency percentages should not overlap. When the percentages overlap, there is not a statistically significant difference in the data at the 95 percent level of probability, and the difference could be due to sampling variation. For example, a 50 percent frequency is not really different from a 55 percent frequency (Appendix M).

Rules for reading frequency transects are necessary in order to provide continuity in the data collected over time. Suggested guidelines include the following:

- Collect the data following the growing season.
- Read the plots at two-step intervals along the transects.
- Count herbaceous plants only if they are rooted in the plot.
- Count trees and shrubs if they are rooted in the plot or if the canopy overhangs the plot.
- Count annual plants if they are rooted in the plot whether they are alive or dead.
- Record ground cover by species, litter or bare ground as "hits" within a designated corner of the plot frame.
- Record rocks smaller than ½ inch in diameter as bare ground

An example of a field sheet used in collecting data is shown in Appendix N. Step point and line point procedures also are commonly used by land management agencies to assess changes in species composition and cover (Bonham 1989).

Riparian and Stream Monitoring – Level Three

Level Three monitoring procedures for streams and riparian areas can be considerably more detailed than what the average ranch requires. However, if more detailed and quantitative vegetation information is required, the same procedures described for Level Three range monitoring will be appropriate for riparian areas, and we will not expand upon those here. Once again, consider enlisting the assistance of a professional range consultant. More intensive monitoring also can be conducted to assess morphological changes to streams, water quality and livestock grazing intensity on riparian vegetation composition and structure. Because the majority of ranchers will not adopt these more intensive monitoring procedures, we have elected in this publication to simply describe what types of measurements are available.

Width to Depth Ratios

Width to depth ratios are sensitive indicators of trend in channel stability. Simply defined, a width-to-depth ratio is the bankfull width of a stream divided by the average depth across the stream where the width was determined. Much scientific literature has been generated to describe what bankfull width is and where it should be measured. For this publication, it can be defined simply as the point on the stream bank where flowing water would access the relatively permanent vegetation. Flows achieving bankfull width have a recurrence interval of about 1.5 years. Transects used to calculate width-to-depth ratios should be marked permanently and located away from point bars and cut banks and in places where the stream is relatively free to meander. Determining the width-to-depth ratios yearly or (annually) is recommended (Rosgen, 1996).

Lateral Stability

The lateral stability of streambanks can be monitored using bank pins. Bank pins are smooth, 6-foot long rods (0.3-0.5 inches in diameter) that are hammered horizontally into streambanks and periodically measured to determine how much of the bank has eroded. Although this methodology involves detailed surveys and calculations to arrive at quantities of soil lost, the technique can be simplified by just recording the length of rod sticking out of the bank and taking photographs. Bank pins should be installed on the outside of bends in the stream and along straight reaches. Readings should be taken following each significant runoff event (Rosgen, 1996).

Livestock Use of Woody Riparian Vegetation

A number of techniques for monitoring livestock use of woody riparian shrubs such as willows and cottonwoods, have been developed. However, most of these are extremely time-consuming, labor intensive and subject to considerable sampling error. One relatively straightforward approach provides an index to woody shrub use based on the percentage of the current year's stem growth removed by browsing ungulates. Woody stems from a representative sample of shrubs are tagged, their lengths measured and recorded. By measuring the same stems again, any net growth or net stem removal can be determined (Cook and Stubbendieck, 1986).

Erosion and Water Quality Monitoring – Level Three

Level Three water quality monitoring involves scientific studies carefully designed to test specific hypotheses. Developing a monitoring program that shows relationships between land use and water quality requires far more investment in time, labor, and financial resources than the average rancher has the ability to commit. In fact, it is difficult for many public agencies, and even scientific research programs, to develop and implement comprehensive water quality monitoring programs. Therefore, we give one example of measuring suspended sediment and mention other available approaches without offering a detailed discussion about how each approach would be implemented.

Increased interest and effort by regulatory agencies, such as the Environmental Protection Agency (EPA) and state regulatory agencies to address nonpoint source (NPS) pollution has prompted discussion about how water quality monitoring might be conducted at the individual ranch level. This approach could increase the number of samples taken across the state and the frequency of sampling at each station. Added to the challenge of implementing broader sampling is the need to develop procedures for monitoring design, sample collection, sample preparation, quality control, shipment to a testing facility, and payment for laboratory analysis. A number of resources that discuss these aspects of water quality monitoring are available. Before a water quality monitoring program is developed, carefully consider these details, and consult with appropriate experts (NMED, 1997; and Stednick, 1991).

Stream Flow and Suspended Sediment Monitoring

Natural variability of stream flow and suspended sediment in surface watercourses makes it difficult to determine timing and amount of sediment delivered from specific locations on a ranch. While exhaustive studies are required to show sediment delivery cause and effect, simple monitoring programs can be valuable in describing baseline sediment delivery and changes in sediment delivery over time.

The stream flow and suspended sediment delivery monitoring example presented here is designed to provide a record of flow and suspended sediment over time. As with range monitoring, these measurements are most useful if conducted every year to show change with differences in climate, grazing practices and other variables on the ranch. Combined with sediment delivery and inventory monitoring of erosion sites, monitoring stream flow and suspended sediment can be useful to show baseline or natural sediment delivery, sediment delivery associated with large storms and sediment delivery related to precipitation variations. Over many years, sediment monitoring can show beneficial effects of improved range management. Most importantly, the sediment monitoring record may be the only data available to show what is actually happening on the ranch. Interpretations of land use effects on sediment delivery require very careful data analysis. Some of the factors to consider when asking broader cause and effect questions are addressed below.

Baseflow monitoring of suspended sediment is most useful to show the amount of fine sediment in the stream flow during low flow periods. The sample for baseflow suspended sediment should be taken before or well after a storm, along with a measurement of flow depth as described in Level One riparian monitoring. Dry sample bottles should be labeled with location, date and time in indelible ink. A grab sample of water should be taken from as close to the middle of the stream as possible and at the midpoint of the stream’s depth. The amount of suspended sediment is measured in milligrams per liter (mg/L), which is the sediment mass divided by the water volume in the sample. Sediment concentration analysis samples may be sent through Cooperative Extension Service county offices to the NMSU Watershed Management Laboratory. Data are recorded as in Example 6 below in the Record of Flow and Water Quality Samples (Appendix O).

Example 6. Data sheet for recording flow and water quality samples.

Date	**Time of Day**	**Stream Depth** (*ft, in*) units	**Stream Width** (*ftt, in*) units	**Sample number**	**Sediment Concentration** (*mg/L*) units
8/17/01	*11:00 AM*	*5”*	*3’*	*Example 1*	*50*
8/18/01	*2:00 PM*	*5”*	*3’*	*Example 2*	*50*
8/18/01	*2:30 PM*	*6”*	*3’*	*Example 3*	*75*
8/18/01	*3:00 PM*	*8”*	*3’ 3”*	*Example 4*	*125*
8/18/01	*3:30 PM*	*1’ 1”*	*3’ 3”*	*Example 5*	*270*
8/18/01	*4:00 PM*	*1’ 0”*	*3’ 6”*	*Example 6*	*240*
8/18/01	*5:00 PM*	*8”*	*3’ 3”*	*Example 7*	*120*
8/18/01	*6:00 PM*	*7”*	*3’*	*Example 8*	*80*
8/18/01	*7:00 PM*	*6”*	*3’*	*Example 9*	*40*
8/19/01	*11:00 AM*	*6”*	*3’*	*Example 10*	*40*

Most sediment is transported during storm events when there is the most surface runoff (with sheet and rill erosion) and channel flow (with gully and streambank erosion). Stream sampling before, during and after a storm provides a snapshot of sediment movement from the upstream watershed to the sampling point. At least three water samples should be taken from the stream during the storm to capture rising, peak and falling parts of the storm hydrograph (fig. 7).

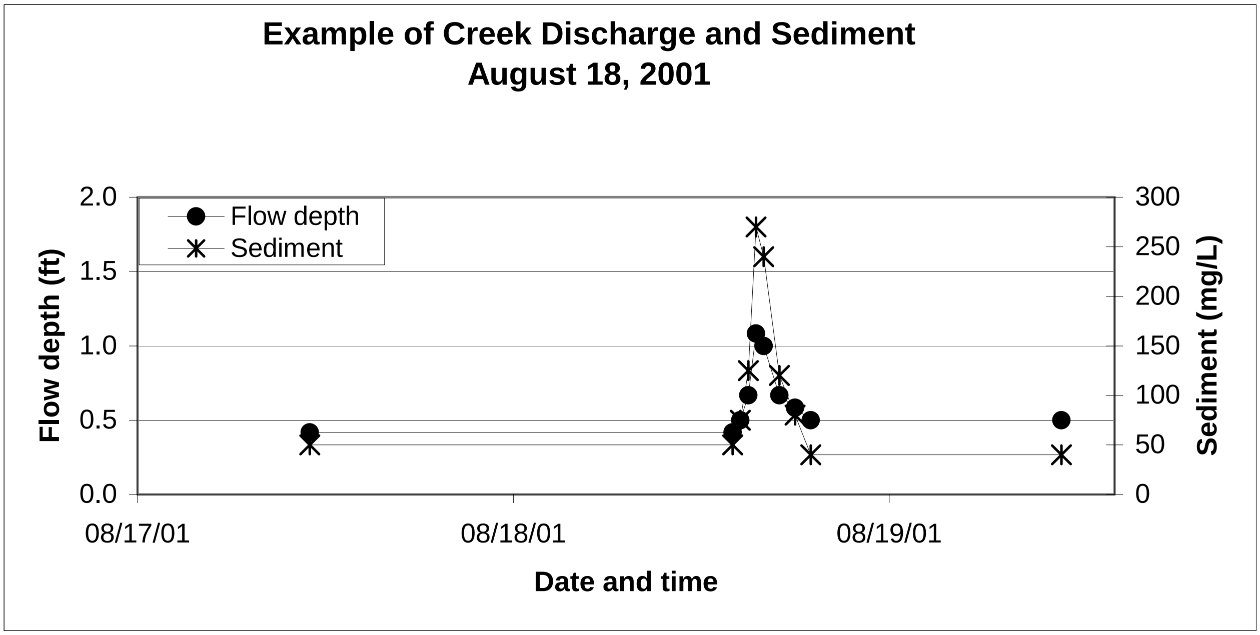


Figure 7. Illustration of data provided by sampling flow depth and suspended sediment before, during and after a storm.

Erosion, Sediment Yield, and Sediment Load

When monitoring and mitigating sediment water quality problems, it is important to distinguish between soil displaced by erosion and soil delivered to streams. **Erosion** occurs in four main categories: surface or sheet erosion, rill erosion, gully erosion and streambank erosion. Sediment is delivered to surface watercourses where surface runoff flow paths meet flowing channels. **Sediment yield** refers to the amount of sediment that is delivered from an entire watershed. **Sediment load** is the amount of sediment delivered per unit of watershed area.

Pollutant load is important, since it is used to evaluate nonpoint source (NPS) pollution in New Mexico under the regulatory mechanism of the Total Maximum Daily Load (TMDL). If the pollutant causing the problem does not come from a defined “pipe” source, and it is transported from throughout the watershed to the impaired stream reach, it is termed a nonpoint source (NPS) pollutant. It is very difficult, if not impossible, to define all source areas of a NPS pollutant in a watershed, so the New Mexico Environment Department develops a TMDL plan and then identifies “potential pollution sources.” These potential sources include all land uses that might cause pollutant transport to streams. Fixing the problem to meet the recommended TMDL is assigned to stakeholders in the watershed through the process of voluntary compliance.

Level Three water quality monitoring includes techniques to monitor the sediment load from a watershed. Carefully determined estimates of sediment load allow range managers to show how much of the total load from a watershed is produced by their grazing lands. Monitoring sediment load can be part of the “best management practice effectiveness monitoring” recommended in TMDL plans. Best management practices to mitigate sediment yields can be part of the TMDL voluntary compliance program. Programs to evaluate sediment load are useful particularly if the watershed area closely corresponds to certain grazing management areas. For example, a small watershed within a ranch, or a few large allotments covering a watershed.

When interpreting studies that estimate sediment load, recognize that the sediment load value only indicates how much sediment comes from a given watershed area. Values for sediment load do not show the sources or causes of sediment production. Grazing practices throughout a watershed may contribute to erosion and sediment yield. Often, however, large volumes of sediment are transported from erosion hot spots, including roads, gullies and streambanks. These erosion sites where sediment can be delivered to streams often have many different historic, natural and management influences. Since erosion often has both natural and human-induced causes, it will be important in future land management planning to develop procedures to assess natural, desirable and tolerable erosion levels.

Few studies exist in New Mexico to show the relationships between grazing practices and watershed sediment yield. This may be a problem for ranchers when grazing is listed as one of the potential pollutant sources in a TMDL or when other regulatory actions target grazing as a cause of sediment yield. Gathering data to show sediment loads from grazed lands can help show the actual sediment contribution from a given rangeland to the total sediment load. As with all Level Three water quality monitoring efforts mentioned, estimating sediment load for a watershed is a time-consuming and difficult process.

Stream flow and sediment sampling in the first example from Level Three water quality monitoring can provide important data for estimating sediment load. For example, if a range manager has measurements of stream depth, stream width and suspended sediment for a storm, a few additional measurements can be collected to calculate storm sediment load. Stream flow can either be calibrated to stream depth with a velocity meter or by Manning’s equation, which requires additional information about channel shape, roughness and slope. Sediment concentration multiplied by stream flow at each measurement interval provides a value for sediment yield. Sediment yield divided by the watershed area gives sediment load for one storm. A carefully designed monitoring program throughout the year can approximate the average annual sediment load for the watershed. This number is directly comparable to the numbers used in TMDL plans.

Instream Water Quality Monitoring

Instream water quality monitoring programs show that there is much variability in rangeland stream water quality (Tate et al., 1999). This variability depends primarily on hydrology and relative amounts of surface and groundwater flows that carry pollutants to streams. On New Mexico rangelands, pollutants of concern carried by surface runoff are sediment, bacteria and nutrients such as nitrogen and phosphorus. Pollutants of concern carried by groundwater are dissolved pollutants, such as salts, metals and nitrate. Representing the variablity of water quality at one location in a stream requires monitoring to capture the type of stream flow that carries the pollutant being studied. Studies of dissolved pollutants should include both baseflow and stormflow, while studies of suspended pollutants might best focus on stormflow.

Long-term studies of rangelands have shown that the timing of storms within the year has a big effect on water quality. Soil moisture, vegetation and litter accumulation, atmospheric deposition and animal inputs all vary with season and affect the amount and timing of pollutant delivery. In addition to variability between storms and between seasons, there is important variability between years. Interannual variation is driven mostly by precipitation but may also reflect management changes. Instream water quality monitoring programs must have clearly defined objectives to produce data that represent the variability in stream water quality.

Land Use and Water Quality Cause and Effect Studies

Variability in watershed hydrology, riparian processes and stream water quality make it particularly difficult to show how grazing affects water quality and stream ecosystems (Rinne, 1999). But these are the effects that managers and regulators often want to understand. A number of study designs have been used in an attempt to show cause and effect. The simplest techniques to infer cause and effect or compare water quality before and after land use changes or upstream and downstream of different land uses. Data that are more statistically powerful are gathered from paired treatments, compare different land uses on similar sites. Possibly the best, but also one of the most difficult types of studies to conduct, is a paired watershed study. In this type of study, years of baseline data show how the hydrology and water quality in the paired watersheds respond with changing climate conditions. Treatments are performed on one watershed, and the differences in response between the treated and untreated watersheds are measured. Most cause and effect studies require scientific study design, sampling and analysis with a large investment of expertise, time and money.

Big Game Monitoring – Level Three

Pellet Group Count Method

Pellet group counts can provide estimates of population size and/or population trends. This method also has been used to determine preferred habitat types and seasonal distribution patterns. An advantage is that this method does not require road access as with spotlight surveys. However, it requires considerable time to establish the pellet group plots initially and collect the subsequent information.

If your objective is to monitor a few sensitive or critical locations such as riparian or cropland areas affected by depredation, then the number of pellet group plots placed within each sensitive area needs to be maximized. Multiple pellet group plots located on a sensitive area will provide data that represents what is occurring on those few, but critical areas.

Conversely, if your objective is to monitor big game populations across your entire ranch, then the key area method previously described will be the most effective approach to obtaining an overall population estimate. In this case, the number of pellet group plots established should be distributed across as many individual key areas as possible. While there is no fixed number to establish per key area, we suggest using three pellet group plots per area. Using more than three may consume limited resources, such as time and materials, that may be better used by distributing them across multiple key areas. Using three plots per key area will give you information that is more representative than one plot per area. However, if you only have the resources to establish and monitor one plot per key area, then by all means do so. Do not allow the inability to establish three plots per key area to dissuade you from monitoring.

Once your key areas have been selected, identify those areas **within** the key areas that you believe are most representative and place the pellet group plots in those locations. If you proceed in this manner, not only are the key areas representative of the entire ranch, but plot placement also accurately represents each individual key area.

1. Establish permanent pellet group plots using brightly painted 18-to-24-inch rebar stakes. Do not move these plots once they have been established. Determine the circular plot boundaries using an 11-foot, 9-inch dog chain with a 1.5-inch diameter, metal key ring attached to one end. Using chain of this length allows sampling of an area that is 0.01 acre in size.

2. Place the key ring over the plot stake, pull the chain taut and walk in a 360° circle to determine the pellet group plot boundary (fig. 8).

3. When the plots are first established, all fecal pellets within the plot boundary must be marked with spray paint, crushed with the foot or removed. Be certain to record the date the pellet group plots were cleared for the first time on the Pellet Group Count Sheet (Appendix P).

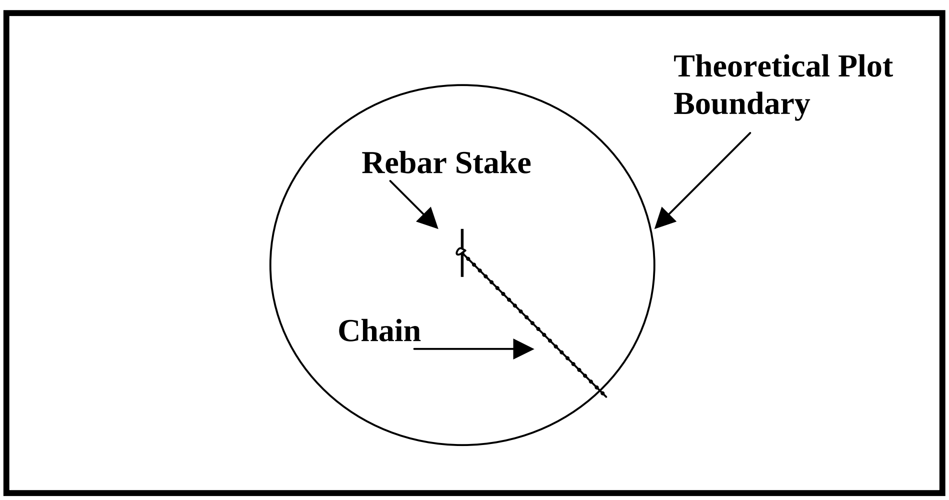


Figure 8. A typical pellet group plot.

4. Pellet group data are best collected using two observers who circle the pellet group plot and mark pellet groups. Pellet group data can be collected using just one observer, but this will increase the time spent collecting data and extra care must be given to ensure pellet groups are not missed.

5. Mark pellet groups with bright orange, red or yellow spray paint.
   - Painting the pellet groups facilitates the counting process, helps prevent counting pellet groups twice and prevents previous deposited pellet groups from being counted during the next collection period.
   - Using a trigger handle for spray cans takes less time and is more ergonomic.

6. A minimum of 15 pellets of the same size, shape and age is a good standard for what constitutes a pellet group. In addition, the majority (> 50 percent) of pellets in a group have to occur within the pellet group plot boundary to be counted. The number of pellet groups counted in each pellet group plot are then recorded on the Pellet Group Count Sheet (Appendix P).

7. Pellet group data can be collected following the same time frames as outlined in the Level Two monitoring section or with time frames that best suit your objectives. It usually is necessary to allow at least two to three months to elapse between data collections in order to obtain meaningful data sets. An even greater time span may be necessary in areas of low animal density. If your ranch undergoes severe winters with persistent snowpack, then mid-winter surveys obviously will not be possible.

8. Once the field data has been collected, use the following formula to estimate elk, deer and/or pronghorn density:

   Number of deer, elk or pronghorn/section = (G x R x A) ÷ (D x T)

   Where:

   G = Number of pellet groups per plot(s)
   R = Reciprocal of area sampled per section.
   A = Area for which density estimate is being made (640 acres).
   D = Daily defecation rate.
   T = Elapsed time in number of days since the last estimate.

   Notes:
   - If you have more than one pellet group plot per key area, then average the number of pellet groups found across all plots on the key area and plug this value in for G.
   - If you have 3 plots in your key area, then plug the value 33.33 in for R. The reciprocal of the area sampled is 33.33, because there are 3, 0.01, acre pellet group plots per site. Three plots x 0.01 acre = 0.03 or 3/100 acre. The reciprocal of the fraction 3/100 is 100/3 or 33.33.
   - Plug in 13 for D because the daily defecation rate is 13 pellet groups/day/elk, deer, or pronghorn.

Therefore, the formula functions in the following manner:

Number of deer, elk or pronghorn/section = (Average number of pellet groups per key area x 33.33 x 640) ÷ (13 x the number of days since plots last read).

Example of Spring/Summer Deer Density for 1997
Assume the following:
You are interested in estimating the spring/summer deer density for a three section tract of land located on a New Mexico ranch. You established three pellet group plots per key area and identified a total of five key areas. These plots were cleared for the first time on April 1, 1997. The following data were collected from the pellet group plots on October 1, 1997.

Example 7. Deer pellet group data collected in 1997:

Date	Key Areas	**Average** number of deer pellet groups for each key area
Oct. 1, 1997	#1	3
Oct. 1, 1997	#2	4
Oct. 1, 1997	#3	2
Oct. 1, 1997	#4	3
Oct. 1, 1997	#5	6

Note: Pellet group numbers above were derived by averaging the number of pellet groups observed across all three plots within each key area.

Deer density calculations for each key area are as follows:

Key Area 1.
Number of deer/section = (3 pellet groups x 33.33 x 640 acres) ÷ (13 pellet groups/day/deer x 182 days) = 27 deer/section

Key Area 2.
Number of deer/section = (4 pellet groups x 33.33 x 640 acres) ÷ (13 pellet groups/day/deer x 182 days) = 36 deer/section

Key Area 3.
Number of deer/section = (2 pellet groups x 33.33 x 640 acres) ÷ (13 pellet groups/day/deer x 182 days) = 18 deer/section

Key Area 4.
Number of deer/section = (3 pellet groups x 33.33 x 640 acres) ÷ (13 pellet groups/day/deer x 182 days) = 27 deer/section

Key Area 5.
Number of deer/section = (6 pellet groups x 33.33 x 640 acres) ÷ (13 pellet groups/day/deer x 182 days) = 54 deer/section

- Therefore, the average number of deer per section = (27 deer/section + 36 deer/section + 18 deer/section + 27 deer/section + 54 deer/section) ÷ 5 = 32 deer per section

- Therefore, the estimated total number of deer on the 3 sections we monitored for spring/summer 1997 = 32 deer/section x 3 section = 96 deer

Conclusions

Developing a monitoring program for your ranch can appear to be a daunting task. However, Level One and even Level Two monitoring techniques provided in this publication can be established easily and data can be gathered quickly. Because of the diversity of rangelands, issues and monitoring objectives facing ranchers across New Mexico, no single approach can be advocated or universally adopted. A monitoring program must be adapted to site-specific needs and considerations. Remember, the best monitoring program is one that was started yesterday or better yet, 10 years ago. We strongly encourage you to start your monitoring with Level One today.

For further information about developing a monitoring program on your ranch, contact your local county agricultural Extension agent.

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APPENDIX A

RANGE MONITORING DATA SHEET

Ranch __________________________ Allotment __________________________ Pasture __________________________

Date ________________

Key Area Location	Number and Class of Livestock	Date In	Date Out	Photo Taken Y/N Location, Date	Relative Use Score & Date	Production Score & Date	Remarks & Incidences
					1=None to Slight 2=Light 3=Moderate 4=Heavy 5=Severe	1=Extreme Drought 2=Below Average 3=Average 4=Above Average 5=Extremely High	

PRECIPITATION DATA SHEET

RANCH______________________________ SITE __________________________________
PASTURE ______________________________ DATE _________________________________
ALLOTMENT ____________________________ PERSONNEL ___________________________

DATE	AMOUNT (INCHES)	DATE	AMOUNT (INCHES)	DATE	AMOUNT (INCHES)
1/1/2000	0.25 (6 in. snow)		EXAMPLE		
6/1/2000	1.25 in. rain				

LEVEL ONE RIPARIAN MONITORING DATA SHEET

RANCH________________________________ SITE (include stream) ______________________

PASTURE ______________________________ DATE__________________________________

ALLOTMENT ____________________________ PERSONNEL ____________________________

DETAILED DESCRIPTION OF LANDSCAPE-LEVEL PHOTOGRAPH LOCATION

____

____

DETAILED DESCRIPTION OF GROUND-LEVEL PHOTOGRAPH LOCATION

____

____

DETAILED DESCRIPTION OF CHANNEL PHOTOGRAPH LOCATION

____

____

RECORD OF FLOW EVENTS

DATE	DEPTH	WIDTH	ACCESSED FLOODPLAIN (Y/N)	DATE	DEPTH	WIDTH	ACCESSED FLOODPLAIN (Y/N)

RECORD OF FLOW EVENTS cont.

DATE	DEPTH	WIDTH	ACCESSED FLOODPLAIN (Y/N)	DATE	DEPTH	WIDTH	ACCESSED FLOODPLAIN (Y/N)

EROSION PHOTO POINT RECORD SHEET

Site # _____ Location Description ______________________________

Monitoring Site Location Map

Photo Point Location and Heading

Photo Point (Site #)	**Compass Heading**	**Landmarks**
Photo Point # (a)		
Photo Point # (b)		
Photo Point # (c)		

Photo Point Location and Heading

Date	Time	Photo Point #	Roll # / Frame #	Photographer	Notes

TRACK COUNT SURVEY SHEET

Observer Name(s) Driver____

Passenger____

Mode of Travel_______________________________________

Time Route(s) Began_______________ Time Route(s) Ended______________

Weather ____

Temperature (F°) __________
Condition of Ground__________________________________

Other____

Remarks____

____

____

____

TRACK COUNT

	Date	Route No.	No. of Elk Tracks	No. of Deer Tracks	No. of Pronghorn Tracks
Day 1		1			
		2			
		3			
Day 2		1			
		2			
		3			
Day 3		1			
		2			
		3			

Note: Use dot count method for recording tracks in table.

APPENDIX F

TRACK COUNT SURVEY SUMMARY SHEET

Location and Description of Route(s) (also see attached map)

____

____

____

____

____

Summary

	Route No.	**Date**	**No. Elk Tracks**	**No. Deer Tracks**	**No. Pronghorn Tracks**
Day 1	1				
	2				
	3				
		Average			
Day 2	1				
	2				
	3				
		Average			
Day 3	1				
	2				
	3				
		Average			
Average Across All Days The average of day 1, 2 & 3 averages for each species.					
Previous Year's Average					
Trend (expressed as change in a percentage)					

CROSS-SECTION TRANSECT DATA SHEET
(Use one sheet per transect)

RANCH ______________________________ **SITE** (include stream) ______________________
PASTURE ______________________________ **DATE** ______________________________
ALLOTMENT ____________________________ **PERSONNEL** __________________________
TRANSECT NUMBER AND DESCRIPTION ____

Sketch (optional)

Community Type (include dominant species and gravel bars, bare ground, etc.)	Total Steps	Community Type %
Total		

GREENLINE TRANSECT DATA SHEET
(Use one sheet per stream reach sampled)

RANCH ______________________________ SITE (include stream) ______________________
PASTURE ______________________________ DATE ______________________________
ALLOTMENT ___________________________ PERSONNEL ___________________________

Sketch (optional)

Community Type (include dominant species and logs, boulders, etc.)	Right Side of Stream			Left Side of Stream	
	# of Steps	Comm. Type %		# of Steps	Comm. Type %
Total					

APPENDIX I

WOODY SPECIES STATUS DATA SHEET

RANCH ______________________________ **SITE** ___________________________________

PASTURE _____________________________ **DATE** ________________________________

ALLOTMENT __________________________ **PERSONNEL** _________________________

LOCATION AND DESCRIPTION ____

Species	Seedling/Sprout		Young/Sapling		Mature		Decadent		Dead	
	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Total										
Total (left and right)										

Average Height (ft)

Tree Layer	
Shrub Layer	
Herb Layer	

EROSION AND SEDIMENT DELIVERY MONITORING WORKSHEET

SITE # _____ **LOCATION DESCRIPTION** ____________________________________

SITE SELECTION CRITERIA (select Yes or No)

Y / N Deliverable to surface water? Y / N Responsive to mitigation?

Y / N Management caused?

SEDIMENT VOLUME (yards^3)

Eroded volume: H=______ L = _______ W = _______ Volume (H*L*W)=_____

Potential volume: H=______ L = _______ W = _______ Volume (H*L*W)=_____

% Deliverable (select one) ____ 0-30% ____ 30-70% ____ 70-100%

UNSTABLE AREAS (for sediment source sites without a "Y" for all three site selection criteria)

☐ Photo monitoring ☐ No monitoring

LOCATION CATEGORY (select one)

☐ Road ☐ Riparian ☐ Hillslope / uplands

EROSION PROCESS (select one)

☐ Streambank erosion ☐ Sheet erosion ☐ Rill erosion ☐ Gully erosion

INFLUENCE (select all that apply)

☐ Road drainage design ☐ Road fill failure ☐ Historical ☐ Livestock grazing

☐ Culvert design ☐ Road cut failure ☐ Natural ☐ Livestock trail

☐ Stream channelization ☐ Dam or spillway ☐ Wildlife grazing ☐ Crop agriculture

☐ Shrub encroachment ☐ Woodland encroachment ☐ Other ___________________

POTENTIAL CONTROL MEASURE (select all that apply)

☐ Road improvement ☐ Channel grade stabilization ☐ Grazing management

☐ Surface treatment ☐ Streambank protection ☐ Monitoring

PRIORITIZATION (See table below for points)

	Description	Points
Assistance needed	______________________________	_____
Estimated time	______________________________	_____
Estimated cost	______________________________	_____
Potential volume (from SEDIMENT VOLUME above)	________________________	_____
% Deliverable (from SEDIMENT VOLUME above)	________________________	_____
	TOTAL PRIORITY SCORE =	_____

Prioritization Table

Assistance Needed	Pts.	Time	Pts.	Costs	Pts.	Potential Volume	Pts.	% Deliverable	Pts.
Technical	1	> Week	1	> $10,000	1	10-100 yd^3	2	0-30%	2
Some	2	1 Week	2	$1000-10,000	2	100-200 yd^3	4	30-70%	5
Minimal	3	1 Day	3	$100-1000	3	200-500 yd^3	6	70-100%	8
None	4	< Day	4	<$100	4	>500 yd^3	8		

SPOTLIGHT SURVEY COUNT SHEET

Observer Name(s) Driver__________________ Passenger________________________
Time Route(s) Began________________ Time Route(s) Ended_________________
Weather ______________________________ Temperature (F°)_____________
Check one Clear____ Partly Cloudy____ Overcast____
Check one No Wind ____ Slight Breeze____ Windy _____
Remarks____

OBSERVATIONS

	Date	Route No.	Females			Males			Fawns or Calves			Unknown			Total		
			E	D	P	E	D	P	E	D	P	E	D	P	E	D	P
1st Night		1															
		2															
		3															
2nd Night		1															
		2															
		3															
3rd Night		1															
		2															
		3															

Note: E = Elk, D = Deer, P = Pronghorn. Use dot count method for recording number of individuals in table.

SPOTLIGHT SURVEY SUMMARY SHEET

Survey Period From ________________________ to _________________________

Location and Description of Route(s) (also see attached map)

____

____

____

____

____

____

Mode of travel:____

Observer Names: Driver ________________Passenger __________________________

Summary

	Route No.	Habitat Type	Females			Males			Fawns or Calves			Unknown			Total		
			E	D	P	E	D	P	E	D	P	E	D	P	E	D	P
1st Night	1																
	2																
	3																
2nd Night	1																
	2																
	3																
3rd Night	1																
	2																
	3																
Ave. of Route 1																	
Ave. of Route 2																	
Ave. of Route 3																	

Bull/Cow Ratio	Buck Deer/Doe Ratio	Pronghorn Buck/Doe Ratio
Elk Density	Deer Density	Pronghorn Density
Total Elk Population	Total Deer Population	Total Pronghorn Population
Trend of Elk Population (% change)	Trend of Deer Population (% change)	Trend of Pronghorn Population (% change)

Note: To calculate population information, use formulas outlined on pages 25 and 26.

APPENDIX M

PROBABILITY TABLE

FREQ.%	CI %	FREQ.%	CI %	FREQ.%	CI %	FREQ.%	CI %
0	0-4	26	18-36	51	41-61	76	67-84
1	0-5	27	19-37	52	42-62	77	68-85
2	0-7	28	19-38	53	43-63	78	69-86
3	1-8	29	20-39	54	44-64	79	70-86
4	1-10	30	21-40	55	45-65	80	71-87
5	2-11	31	22-41	56	46-66	81	72-88
6	2-12	32	23-42	57	47-67	82	73-89
7	3-14	33	24-43	58	48-68	83	74-90
8	4-15	34	25-44	59	49-69	84	75-91
9	4-16	35	26-45	60	50-70	85	76-91
10	5-18	36	27-46	61	51-71	86	78-92
11	5-19	37	28-47	62	52-72	87	79-93
12	6-20	38	28-48	63	53-72	88	80-94
13	7-21	39	29-49	64	54-73	89	81-95
14	8-22	40	30-50	65	55-74	90	82-95
15	9-24	41	31-51	66	56-75	91	84-96
16	9-25	42	32-52	67	57-76	92	85-96
17	10-26	43	33-53	68	58-77	93	86-97
18	11-27	44	34-54	69	59-78	94	88-98
19	12-28	45	35-55	70	60-79	95	89-98
20	13-29	46	36-56	71	61-80	96	90-99
21	14-30	47	37-57	72	62-81	97	92-99
22	14-31	48	38-58	73	63-81	98	93-100
23	15-32	49	39-59	74	64-82	99	95-100
24	16-33	50	40-60	75	65-83	100	96-100
25	17-35	FREQ. = Frequency			CI = Confidence Interval		

APPENDIX N

POINT/FREQUENCY DATA SHEET

RANCH ______________________________ **ALLOTMENT** ____________________
PASTURE _____________________________ **TRANSECT NO.** __________________
NO. QUADRATS ________________________ **PLOT SIZE** ______________________
EXAMINERS ____

POINT	**GROUND COVER TALLY**		**TOTAL**	**%**
BARE GROUND				
Rock (>1/2”)				
Litter				
Live Veg. (Basal)				
SPECIES LIST		**FREQ. TALLY**	**TOTAL**	**%**
Tree, Shrub, Half Shrub				
Perennial Grass				
Perennial Forb				
Annual				

Note: Provide any general observations on back.

RECORD OF FLOW AND WATER QUALITY SAMPLES

Date	Time of Day	Stream Depth ( ) units	Stream Width ( ) units	Sample Number	Sediment Concentration ( ) units

APPENDIX P

PELLET GROUP COUNT SHEET

Observer Name(s) _________________________ and ___________________________

Remarks ____
____
____
____

Pellet Group Counts

Key Area Number	Habitat Type	Date Sampled	Pellet Group Plot Number	No. Elk Pellets Groups	No. Deer Pellet Groups	No. Pronghorn Pellet Groups
#1			1			
			2			
			3			
#2			1			
			2			
			3			
#3			1			
			2			
			3			
#4			1			
			2			
			3			
#5			1			
			2			
			3			

Note: Use dot count method for recording pellet groups in table.

PELLET GROUP COUNT SUMMARY SHEET

Survey Period From ________________________ to ________________________

Location and Description of Key Areas and Pellet Group Plots (also see attached map)
____
____
____
____

Summary

Key Area Number	Habitat Type	Date Sampled	Pellet Group Plot Number	No. Elk Pellet Groups	No. Deer Pellet Groups	No. Pronghorn Pellet Groups
#1			1			
			2			
			3			
			Average			
#2			1			
			2			
			3			
			Average			
#3			1			
			2			
			3			
			Average			
#4			1			
			2			
			3			
			Average			
#5			1			
			2			
			3			
			Average			

Elk Density	Deer Density	Pronghorn Density
Total Elk Population	Total Deer Population	Total Pronghorn Population
Trend of Elk Population (% change)	Trend of Deer Population (% change)	Trend of Pronghorn Population (% change)

Note: To calculate population information, use formulas outlined on pages 37 and 38.